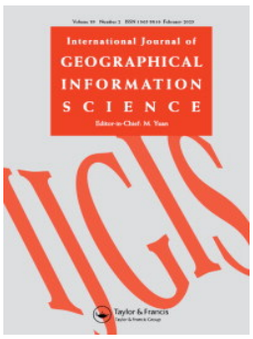

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Optimizing recruitment in an online environmental PPGIS—is it worth the time and costs?

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ABSTRACT

Public participation GIS surveys use both random and volunteer sampling to recruit people to participate in a self-administered mapping exercise online. In random sampling designs, the participation rate is known to be relatively low and biased to specific segments (e.g. middle-aged, educated men). Volunteer sampling provides the opportunity to reach a large crowd at reasonable costs but generally suffers from unknown sampling biases and lower data quality. The low participation rates and the quality of mapping question the validity and generalizability of the results, limiting their use as a democratic tool for enhancing participation in spatial planning. We therefore asked: How can we increase participation in online environmental PPGIS surveys? Is it worth the time and costs? We reviewed environmentally related online PPGIS surveys ($n = 26$) and analyzed the sampling biases and recruitment strategies utilized in a large-scale online PPGIS platform in coastal areas of northern Norway via both random (16,978 invited participants) and volunteer sampling. We found that the time, effort, and costs required to increase participation rates yielded meager results. We discuss the time and cost efficiency of different recruitment methods and the implications of participation levels despite the recruitment methods used.

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KEYWORDS
PPGIS; recruitment; participation rate; sampling bias; cost efficiency

Introduction

A public participation geographic information system (PPGIS) is a collection of methods and technologies that aim to engage the public in mapping their values, experiences, knowledge, preferences, and concerns for the purpose of inclusive monitoring, planning or decision-making (Sieber 2006, Brown and Kyttä 2014). The concept of PPGIS emerged at a meeting at the National Centre for Geographical Information and

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Analysis in the U.S. in 1996 but is closely associated with participatory GIS (PGIS), which aims to map local spatial knowledge by combining participatory learning and action methods with GIS to empower people in rural areas of the Global South (Brown and Kyttä 2014, Verplanke *et al*. 2016, Denwood *et al*. 2022). In recent years, online PPGIS has provided new opportunities to engage with a larger number of citizens to map local spatial knowledge by drawing on the technological capabilities of Web 2.0. Online PPGIS provides underrepresented groups, or the 'silent majority', with a new platform for participating in planning and decision-making (Brown and Fagerholm 2015). In addition to engaging participants who prefer to raise their voices anonymously, these platforms can offer people with physical disabilities and those living in remote locations with a more convenient participation method compared to public meetings (Kantola *et al*. 2023, Kotus and Rzeszewski, 2023). In this way, online PPGIS could complement existing participatory processes to create maps together with citizens.

Despite the promises of online PPGIS presented in the scientific literature, the tool has, to only a limited extent, become a part of mainstream environmental planning and decision-making (Kantola *et al*. 2023). One of the reasons could be the lack of knowledge about who participates in online PPGIS and the quality of the data provided by such tools (Brown 2017). For these tools to be used by environmental and natural resource managers on equal terms, such as expert-driven collection of spatial information, there is a need to better understand how usability and research design, as well as sampling strategies, influence who is participating and the kind of data that participants are likely to provide by mapping online.

The sampling strategy is important for ensuring the quality of the data obtained from online PPGIS. For example, data collected from convenience sampling have a lower quality than data collected from random sampling, as measured by the time spent and the number of features mapped. Random sampling is a probability sampling method (Noor *et al*. 2022) where participants are identified randomly from a population of persons who meet the demographics to be included in the study (Emerson 2015) and where each individual has the same probability of being selected on the basis of the given criteria (Noor *et al*. 2022). Convenience sampling, i.e. volunteer sampling, where individuals are self-selected, has been primarily used as a less costly alternative to random sampling. Convenience sampling automatically includes biases since not every individual has the same probability of being selected (Farrokhi and Mahmoudi 2012), and it is unsure who the data represent (Golzar *et al*. 2022). Volunteer sampling has limited generalizability due to the unknown characteristics of participants (Mullinix *et al*. 2015); therefore, it is not possible to generalize the results to the overall population or beyond a specific case (Acharya *et al*. 2013, Mweshi and Sakyi 2020). Given that the quality of PPGIS data is lower for convenience sampling than for random sampling (Brown 2017), it is worthwhile to invest in random sampling strategies to gain sufficient quality data provided for decision-making.

The reason why randomly sampling participants requires more effort in mapping is probably due to the need to issue personal invites to participants, which also allows the identification of who is participating and contributing to data collection (Emerson 2015). Even though minor biases are undeniable in sampling (Mweshi and Sakyi 2020), e.g. owing to outdated mailing lists, a greater challenge is response bias, either by low

recruitment of participants in general or higher participation of middle-aged men with high education and income (Hausner *et al*. 2015, Brown 2017).

The lower participation in online PPGIS compared with paper-based PPGIS surveys is well known, with a participation rate of approximately 13% in online PPGIS compared with PPGIS using paper-based surveys, which range between 18% and 45% (Beverly *et al*. 2008, Brown and Reed 2009, Brown 2012, Brown *et al*. 2012). Nonparticipation in PPGIS has not been adequately researched (Pocewicz *et al*. 2012), and the overall decline in survey participation, both in conventional and nonconventional surveys (de leeuw *et al*. 2002, Curtin *et al*. 2005, Hansen, 2006, Manfreda *et al*. 2008), is of particular concern for the purpose of comparing results between years and across sites. Given the importance of allowing people to enter the platform to start mapping, there is a need to understand who is responding to an online PPGIS survey. It could be beneficial for decision-makers and planners to also know the costs of increasing the participation rate of different sociodemographic groups compared with other methods to target specific users.

In this study, we asked, 'How can optimizing recruitment strategies increase participation in online PPGIS and what are the costs?' Recruitment strategies are the methods used to increase participation in online PPGIS, such as mail-based invitations to random households, email list invitations and traditional and social media. To examine different ways of optimizing recruitment strategies, we first reviewed environmental PPGIS studies ($n = 26$) using random sampling, along with different methods and strategies for increasing participation rates among different groups. We limited ourselves to online PPGIS studies relevant to natural resource management, environmental studies, and biodiversity conservation. We evaluated their recruitment methods, participation rates, recruitment and sampling biases and possible reasons and solutions for overcoming response biases. We analyzed the relationships between the different recruitment methods and the effects of the participation rate on representativeness and data quality. Second, we compared these results to our large-scale PPGIS study in coastal northern Norway, where we sampled 16,978 households, in addition to convenience sampling via traditional and social media. We evaluate the results of the different methods used for recruitment, the costs of the PPGIS survey, and the data quality and validity. We originally chose a large-scale study for four main reasons: (i) the study is part of the Coastal Barometer, which aims to measure sustainability in all coastal municipalities in northern Norway; (ii) the coast of northern Norway is changing due to blue growth (i.e. long-term sustainable development in the marine and maritime sectors promoted by the European Commission (European Commission 2012)); (iii) possible differences among the regions in a large geographic area; and iv) increasing the representativeness of the overall population.

Materials and methods

Literature review

Relevant publications of online PPGIS surveys using random sampling were identified from a database through participatory mapping, and peer-reviewed journal articles were collected by searching multiple platforms (Web of Science, Scopus, ProQuest and ScienceDirect). We used the following string search: ('public participation geographic information system' OR 'participatory geographic information system' OR 'participatory

geographic information technologies' OR 'participatory mapping' OR 'PPGIS' OR 'PGIS' OR 'PGIT') AND ('environment' OR 'conservation' OR 'climate' OR 'knowledge' OR 'biological diversity' OR 'natural resources' OR 'ecosystem services' OR 'ecology' OR 'ecosystem').

By screening these databases, we found 327 publications that used online PPGIS, of which we chose those that used random sampling. We recorded their recruitment methods, participation rates, possible reasons for low participation, sampling biases, and possible solutions to low participation and sampling biases. We also reported the number of invited participants, geographic location, software, spatial scale, number of mapped markers, and average number of mapped markers per participant in each publication. The aim of the literature review was to assess online environmental PPGIS with random sampling to compare participation rates to those of the recruitment strategy.

Large-scale PPGIS in coastal Norway

The large-scale PPGIS in coastal northern Norway included 81 municipalities in 13 territories: Øst-Finnmark, Vest-Finnmark, Nord-Troms, Tromsø-region, Midt-Troms, Sør-Troms, Ofoten, Vesterålen, Lofoten, Salten, Indre Helgeland, Helgeland and Sør-Helgeland (Figure 1). The area is divided into 13 regional councils that have inter-municipal cooperation and that are responsible for coastal zone planning in Norway (*Marine and coastal waters - Environment Norway*, 2022). The total population in northern Norway is 356,001 (*Statistics Norway,* 2023). The coast in northern Norway is changing due to growth in the blue economic sector (*Developing a Sustainable Blue Economy in the European Union* 2021), resulting in pressures on the use of resources and spaces by multiple users and concerns about their effects on the environment (Arbo and Thůy 2016, Engen *et al*. 2018, Aanesen *et al*. 2023).

Online PPGIS survey

The aim of this large-scale PPGIS survey was to map the values and concerns over coastal development in local communities in northern Norway to better understand the observed and potential societal and environmental impacts of blue growth. The participants were invited to the Maptionnaire Community Engagement Platform (www.maptionnaire.com) (Kyttä *et al*. 2023). Upon entering the Maptionnaire web link to enter the survey (www.mpt.link/kyst, supplemental Appendix I), the participants were greeted by a welcome screen that provided information about the study and the survey. Thereafter, an information and consent page informed about their rights in accordance with the General Data Protection Regulation (GDPR) (Wolford 2020), including check boxes for agreement before continuing to complete the survey. The respondents had to be 18 years of age or older to participate and were informed that they could not be replaced by others. The survey consisted of four components: mapping of places that people value (seven values, including scenic areas, undisturbed nature, biological diversity, local culture/identity, recreation activities, fishing, hunting and gathering, and local income), mapping participants' concerns about current and future changes in the environment (seven concerns, including tourism, aquaculture,

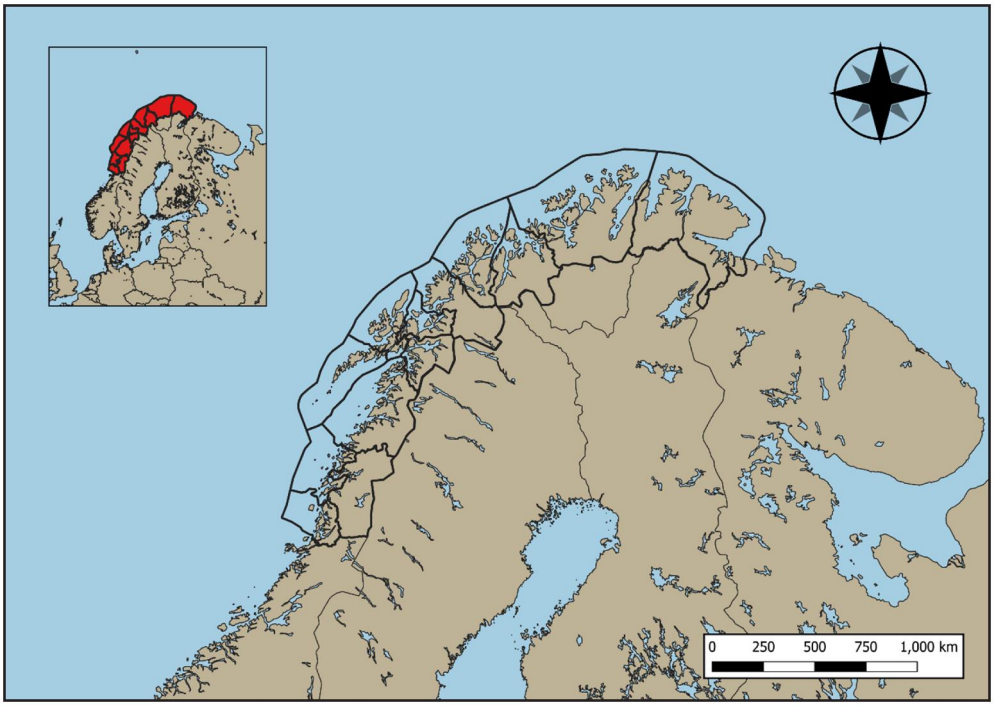

Figure 1. Study area of 13 regions for the large-scale PPGIS in northern Norway. Map created using the free and open source QGIS.

habitat destruction, pollution from industry, overfishing, motorized vehicle use, and area restrictions), mapping any optional values or concerns that were not listed in the survey, and a short questionnaire including questions about place attachment, growth in marine industries and questions about the participants' background. After completing the survey, the participants were asked to register their email address for reporting results back to them and for their willingness to participate in future rounds of follow-up surveys.

Mail-based recruitment using random sampling

We used the same approach to random sampling as Hausner *et al*. (2015) but drew 5% of the population from the tax register, set a minimum number of 100 for the smallest municipalities to ensure participation from these municipalities, and recruited a maximum of 1000 participants from the largest city municipalities (Tromsø 76,974 inhab., Bodø 52,357 inhab.), resulting in 16,978 potential participants in total for all municipalities (Table 1). The participants were contacted by mail with information about the survey and a code for logging in on the website. The respondents were requested to enter an ID code that they had received via mail. This access code links survey responses to individual respondents in later analyses. We contacted newspapers together with a communications advisor at UiT, the Arctic University of Norway, to publish a press release about our study before and between surveys. We performed a lottery for the participants in the form of gift cards.

Table 1. The 81 municipalities and the number of randomly drawn 5% of residents belonging to each municipality in northern Norway.

Municipality	Randomly drawn households aged 18–79, 50 % women and 50 % men	Municipality	Randomly drawn households aged 18–79, 50 % women and 50 % men
Bindal	100	Gratangen	100
Brønnoy	292	Harstad	933
Sømna	100	Ibestad	100
Vega	100	Kvæfjord	108
Vevelstad	100	Lavangen	100
Sør-Helgeland	**692**	Salangen	100
Alstahaug	281	**Sør-Troms**	**1441**
Dønna	100	Senja (incl. Berg (100), Lenvik (430), Torsken (100), Tranøy (100))	730
Herøy	100	Dyrøy	100
Leirfjord	100	Lenvik	0
Rødøy	100	Målselv	255
Træna	100	Sørreisa	130
Vefsn	502	Torsken	0
Helgeland	**1283**	Tranøy	0
Lurøy	100	**Midt-Troms**	**1215**
Hemnes	166	Balsfjord	212
Nesna	100	Karlsøy	100
Rana	985	Tromsø	1000
Indre Helgeland	**1351**	**Tromsø-region**	**1312**
Bodø	1000	Kvenangen	100
Fauske	372	Kåfjord	100
Gildeskål	100	Lyngen	108
Hamarøy (incl. Tysfjord)	152	Nordreisa	184
Meløy	231	Skjervøy	110
Saltdal	175	Storfjord	100
Steigen	100	**Nord-Troms**	**702**
Sørfold	100	Alta	760
Salten	**2230**	Hammerfest (incl. Kvalsund)	496
Ballangen	100	Hasvik	100
Evenes	100	Kvalsund	0
Narvik	749	Loppa	100
Tjeldsund (incl. Skånland)	215	Måsøy	100
Tysfjord	0	Nordkapp	126
Ofoten	**1164**	Porsanger	153
Flakstad	100	**Vest-Finnmark**	**1835**
Moskenes	100	Berlevåg	100
Røst	100	Båtsfjord	100
Vestvågøy	420	Gamvik	100
Værøy	100	Lebesby	100
Vågan	361	Nesseby	100
Lofoten	**1181**	Sør-Varanger	390
Andøy	180	Tana	114
Bø	100	Vadsø	224
Hadsel	304	Vardø	100
Lødingen	100	**Øst-Finnmark**	**1328**
Sortland	392	***TOTAL***	**16,978**
Øksnes	168		
Vesterålen	**1244**		

The text in bold are the regions. We requested the data from the Norwegian Tax Administration and received the data from Evry ASA.

Convenience sampling using newspapers and email lists

We advertised our survey using a paid ad in one local newspaper to increase the visibility of our survey. Toward the end of the random sampling, we contacted local newspapers ($n = 15$) to increase the publicity of the survey for those who had received

a letter. After we had sent the letters, we contacted the same newspapers and other newspapers ($n = 35$ in total) to publish the link to our survey so that anyone could participate. At the start of the survey, participants were asked where they had heard about the survey (e.g. media, social media, friends) so that we could track the effect of our public campaign and distinguish between participants in the random household sampling and the purposive sampling. We e-mailed all 81 municipalities (Table 1) and 40 larger organizations, including organizations related to fisheries (12), outdoor organizations (10), environmental organizations (5), sea traffic organizations (5), unions (3), coastal organizations (2), development organizations (1), tourism organizations (1) and universities (1), that were relevant to our study and requested them to distribute the link of the survey.

Social media

We posted information about our survey on our social media accounts on Facebook (www.facebook.com/kystbarometeret) and Instagram (www.instagram.com/kystbarometeret) to increase the publicity of our study. We tagged and asked organizations to share our posts. We published the survey's link in a post and on our Instagram profile so that anyone aged 18–79 years living in northern Norway was invited to participate. We posted the survey on social media after the random household invitations had been sent out to avoid having those invited by post participate via the social media link instead. We also created an Instagram account for follow-up surveys and for sharing the results of our study. In addition to posting on Facebook and Instagram, we conducted a paid two-week social media campaign to increase volunteer recruitment. We included Snapchat in the campaign to reach younger participants (older than 18 years old).

Time-cost efficiency

We calculated the number of personnel-hours used for the PPGIS study in northern Norway. This included hours for planning and creating the survey; ordering, folding, and sending invitations and reminders; posting on social media and conducting the social media campaign; answering telephone calls, messages and e-mails from participants; conducting a telephone survey of 15 participants, asking about their experience filling out the survey or their reasons for not responding (completed survey (5), unfinished survey (5), nonresponse (5)); and e-mailing organizations and newspapers about the survey. We calculated the costs per household, costs per volunteer, costs for material (license for the Maptionnaire platform, letters, reminders) and the social media campaign.

Validity and quality of the data

We examined the representativeness to validate the data. To assess the quality of mapping, we calculated the number of participants (unfinished and completed surveys), examined participation rates before and after the reminders were sent, the

average number of mapped markers, the average time spent by participants completing the survey, and the values and concerns mapped.

Results

Literature review

Table 2 presents the summarized literature review of environmental PPGIS studies ($n = 26$). We only searched for environmental online PPGIS that used random sampling in their recruitment, and for this reason, the number of papers in the review was small. The literature review is presented in more detail in supplemental Appendix II. Our literature review revealed that all 26 online PPGIS studies were implemented in the Global North. The most common volunteer recruitment methods for online PPGIS studies relevant to natural resource management, environmental studies, and biodiversity conservation were social and traditional media, contacting organizations and recruiting on site (Table 2). The participation rate ranged from very low (1.2%; (Brown *et al*. 2015a) to 21%, the highest rate for an online PPGIS (Beverly *et al*. 2008, Brown and Glanz 2018). The participation rate of online PPGIS surveys using random sampling resulted in a mean value of 11.3%. The reasons for low participation listed by the publications included undelivered letters, poor internet access and participants' low level of digital literacy, lack of reminder letters, wrong timing of surveying and the complexity of the surveys. Participation in PPGIS surveys using random sampling is generally skewed toward middle-aged men with high levels of education and high income (Brown 2017). Online PPGIS using volunteer sampling has managed to recruit younger participants, e.g. through social media in Poland (Brown *et al*. 2015a). Suggested solutions to low participation included using a mixed-method survey to participate, meeting physically at a community center or other arenas to help the participants with the survey, including an instructional video on how to fill out the survey, sending out an additional survey to nonresponse segments, considering the timing of surveying and building trust with locals. Participation in online surveys often excludes the older generation (60+ years old) (Stern *et al*. 2009, Brown *et al*. 2015a, Rzeszewski and Kotus 2019), and volunteer sampling was used to reduce sampling bias and increase representativeness (Brown *et al*. 2017b, Brown and Eckold 2020) (Table 2).

Validity and quality of PPGIS data in Norway

We sent 15,914 letters to 79 municipalities in 12 regions (excluding the pilot region, Sør-Helgeland ($n = 692$) and the municipality Fauske ($n = 372$) due to an administrative error), of which 1883 were returned. We obtained 91 errors in the returned letters (i.e. did not match with a unique ID code), resulting in 11.8% returned letters and 14,122 residents who we expect to receive the letter (19 N/As). A total of 2284 people started the survey ($n = 1909$ randomly sampled residents and $n = 375$ volunteers). A total of 1358 individuals completed the survey ($n = 1238$ randomly sampled residents and $n = 120$ volunteers). We excluded participants who did not map any markers ($n = 737$) from the total number of persons who started the survey ($n = 2284$), resulting in

Table 2. Literature review of online environmental PPGIS surveys that used random household sampling ($n = 26$).

Geographic location	Volunteer sampling used in addition to random sampling	Participation rate	Reasons for low participation	Recruitment and sampling biases	Solutions to low participation and biases	Publication
Canada	1-day drop-in centres	21%	N/A	More men with more formal education and higher income	N/A	Beverly *et al*. (2008)
This study did not focus on a single study					Mixed-method survey	Brown (2017)
New Zealand	Visitors, local media	N/A	N/A	More older men with formal education	N/A	Brown (2012), Brown and Brabyn (2012)
U.S.	None	11.6% (overall), 10.1% (web-based), 19.1% (panel group)	N/A	N/A	Multiple choices of participation modes, internet survey panels, incentives	Brown and Donovan (2014), Brown and Donovan (2013)
U.S.	Social media, university digital newsletter	9.2%	N/A	Older men with higher education, long-term residents with a high proportion of home ownerships	Volunteer sampling (to target younger, short-term residents to participate) to offset demographic biases	Brown and Eckold(2020)
U.S.	Website, community centre	21%	Undelivered letters, discomfort with technology	N/A	Physical meetings, a 'how-to' video for guidance	Brown and Glanz (2018)
U.S.	None	10%	Lacking convenient internet access	Participants were skewed towards persons with college degrees	Survey to ask for non-participation	Brown and Reed (2009)
Australia	None	16.2%	Lower response rate in the web-based survey in comparison to a previous paper-based survey in the same area (and same households), lacking internet access, complex survey	Representativeness not discussed, but the results show that participants were skewed slightly towards middle-aged men	Offering contact details (telephone number and post box) to help participants complete the survey (eight persons called), offering a mixed-method survey	Brown and Weber (2012, 2013)

(*continued*)

Table 2. Continued.

Geographic location	Volunteer sampling used in addition to random sampling	Participation rate	Reasons for low participation	Recruitment and sampling biases	Solutions to low participation and biases	Publication
U.S.	Workshop	In 1998: 30.8%, in 2012: 10.1% (new participants) and 19.1% (for those that participated also in 1998)	N/A	More men in the workshop compared to random sampling in 1998 and 2012. In 1998: more evenly distributed among the communities compared to participants in 2012		Brown *et al*. (2014)
Norway	E-mail, social media	14% (southern Norway), 16.3% (northern Norway)	Internet access problems	Participation bias in presenting more men with higher education	N/A	Brown et al. (2015c)
Norway, Poland	Facebook, home page, municipalities, local associations, institutions, traditional media	14 % (southern Norway), 16.3% (northern Norway), 1.2% (Poland)	Most recruitment through social media, not households (Poland)	Older men with higher education and income (Norway), younger women with higher education (Poland)	Build trust to locals	Brown *et al*. (2015a)
Finland	Social media, traditional media, E-mail, municipalities, ski resorts	∼2% (, $n = 54$), representing 10% of total participation	No reminders, poor internet connection, elderly people with less internet skills	More men (56%) than women (44%)	Volunteer sampling in addition to random household sampling	Brown *et al*. (2017a)
U.S.	E-mail, contacting key groups to distribute the survey	7%	N/A	Middle-aged men (households), higher education and higher knowledge relevant for the study (volunteers)	Mixed-method survey as suggested by Brown and Reed (2009)	Brown *et al*. (2014)
U.S.	None	11.9%	N/A	Respondents highly educated, more knowledgeable about nature and science, and had a strong connection to nature than the average	Non-participation telephone survey, the recommendation of using a mixed-method survey, greater and more targeted recruitment, include a tutorial on ecosystem service concepts in the survey	Brown *et al*. (2012)

(*continued*)

Table 2. Continued.

Geographic location	Volunteer sampling used in addition to random sampling	Participation rate	Reasons for low participation	Recruitment and sampling biases	Solutions to low participation and biases	Publication
Australia	Individual and informal recruitment, E-mail, social media, traditional media, invitation cards, organization newsletters	4% (households), ~ 64% (E-mail), 13% (social media), 8% (personal referral)	Inaccurate postal addresses, many returned letters	Younger and more highly educated participants. More mapped points for coastal and marine conservation	Timing of a survey. The timing may influence who participates due to external factors, which in turn affects the mapping results and participation rate	Brown *et al.* (2016)
Australia	Online panelists	12% (first round), 4% (second round)	N/A	N/A	N/A	Brown *et al.* (2012)
Norway	Local organizations, social media, traditional media	14% (southern Norway), 16.3% (northern Norway)	N/A	More men with higher levels of formal education and higher income	N/A	Engen *et al.* (2018)
Norway	Organizations	14%	Internet access problems	More men with higher education	N/A	Hausner *et al.* (2015)
Australia	Key informants ($n = 48$), volunteers through family, work, friends	11.7% (web-based), 44.6% (paper-based)	N/A	N/A	Postcards were sent to households to ask for non-participation	Karimi *et al.* (2015)
Norway	Social media, traditional media, interviews	14% (households), 14.7% (park entrances)	N/A	Skewed towards men with higher education	Feedback from participants to develop an instructional video and a document of frequently asked questions	Muñoz *et al.* (2019)
U.S.	None	7% (web-based), 17% (paper-based)	N/A	Age bias: participants in the web-based survey were skewed towards persons with college degrees	Non-participant telephone survey, mixed-method survey	Pocewicz and Nielsen-Pincus (2013), Pocewicz *et al.* (2012)
U.S.	Newspaper, radio, postings at different locations (e.g. library, town hall, grocery stores)	18% (paper and web-based combined), 10% (web-based), 8% (paper-based)	Error in login code in the third letter that was sent to households, complexity of the survey (feedback from participants)	Older men with higher education	A two-time non-response test to assemble sampling bias, non-participant telephone survey. Response rate would have been lower without the mixed-method survey	Schroeder (2014)

Table 3. PPGIS data on participation in northern Norway.

Region	Letters/reminders	Number sent	Number participated, unfinished surveys	Participation rate, unfinished surveys (%)		Number participated, completed surveys	Participation rate, completed surveys (%)	
Helgeland	Letters	1173	75	6.4		66	5.6	
Helgeland	Reminders	1083	58	5.4	11.3	50	4.6	9.9
Indre Helgeland	Letters	1204	79	6.6		67	5.6	
Indre Helgeland	Reminders	1080	28	2.6	8.9	26	2.4	7.7
Salten	Letters	1652	112	6.8		94	5.7	
Salten	Reminders	1488	43	2.9	9.4	39	2.6	8.1
Ofoten	Letters	1056	52	4.9		45	4.3	
Ofoten	Reminders	981	47	4.8	9.4	39	4.0	8.0
Lofoten	Letters	1072	60	5.6		50	4.7	
Lofoten	Reminders	996	27	2.7	8.1	24	2.4	6.9
Vesterålen	Letters	1127	0	0		0	0	
Vesterålen	Reminders	1055	89	8.4	8.4	73	6.9	6.5
Sør-Troms	Letters	1288	64	5.0		57	4.4	
Sør-Troms	Reminders	1213	35	2.9	7.7	27	2.2	6.5
Midt-Troms	Letters	1062	55	5.2		49	4.6	
Midt-Troms	Reminders	1011	58	5.7	10.6	52	5.1	9.5
Tromsø-region	Letters	1159	100	8.6		92	7.9	
Tromsø-region	Reminders	1088	31	2.8	11.3	24	2.2	10.0
Nord-Troms	Letters	601	38	6.3		33	5.5	
Nord-Troms	Reminders	601	34	5.7	12.0	31	5.2	10.6
Vest-Finnmark	Letters	1604	91	5.7		77	4.8	
Vest-Finnmark	Reminders	1604	16	1.0	6.7	12	0.7	5.5
Øst-Finnmark	Letters	1143	51	4.5		44	3.8	
Øst-Finnmark	Reminders	1143	38	3.3	7.8	35	3.1	6.9
N/A		19						
Total	Letters	14,141	1281	9.1		1106	7.8	

$n = 1547$ participants who contributed data (supplemental Appendix IV). Volunteers that mapped at least one marker ($n = 185$, 11 N/As) were recruited through different channels as follows: Instagram (67), Facebook (44), advised by someone (25), other (19), other websites (11) and newspapers (8). Our tutorial video in the mapping component was viewed 609 times.

Similar to previous PPGIS studies (Brown 2017), our results on participants were biased toward middle-aged men with high education and high levels of income. In the random sample, more men ($n = 695$) than women ($n = 466$) participated. The median age of the participants from the random sampling was 55 years. In volunteer sampling, the number of men who participated was $n = 59$, and the number of women who participated was $n = 50$ (75 N/As). The median age was 48 years (supplemental Appendix V).

Table 3 presents the participation rates for each region after sending the invitations and the reminders. We have divided the data into unfinished (i.e. mapped at least one marker) and completed surveys in the table. The total participation rates for unfinished surveys ranged between 6.7% (Vest-Finnmark) and 12.0% (Nord-Troms), and those for completed surveys ranged between 5.5% (Vest-Finnmark) and 10.6% (Nord-Troms). Participation increased considerably after reminders were sent. The overall participation rates for all of northern Norway were 9.1% and 7.8% for unfinished and completed surveys, respectively. The response rates for the studies included in our review (online, random sampling) had a mean value of 11.3%; our response rates closely tracked these rates, with an average rate of 9.1%. Our mean participation rate also

aligns with those of PPGIS studies that used random sampling and online and passive recruitment, with a mean participation rate of 11.2%.

A total of 17,452 markers were mapped, of which 17,240 (including 'Where do you live?') were inside the study area. A total of 17,229 markers were from a known recruitment strategy, of which 14,826 markers were mapped by 1362 participants recruited through random sampling and 2403 markers were mapped through volunteer sampling ($n = 185$). Randomly selected participants mapped six markers on average and volunteers mapped five markers on average. Participants that placed $n \geq 50$ markers on the map, defined as 'supermappers' (Muñoz *et al.* 2020), accounted for 25 persons, of whom 18 were randomly sampled and seven were volunteers (supplemental Appendix VI). There was no difference between the values from randomly sampled residents and those from volunteers (Figure 2(a)).

The highest number of mapped values for both randomly sampled and volunteers was 'scenic areas', followed by 'recreation activities', 'fishing, hunting and harvesting', 'undisturbed nature' and 'local culture or identity'. The mapping of randomly sampled residents and volunteers differed only in regard to the two remaining values, 'biological diversity' (higher for randomly sampled residents) and 'local income' (higher for volunteers). There were 225 and 30 'other values' mapped by randomly sampled and volunteers, respectively.

The highest number of mapped concerns for both randomly sampled individuals and volunteers was 'aquaculture'. Other concerns, such as tourism or industrial pollution, were consistently present in both groups, whereas overfishing or area restrictions were less prominent. Randomly selected and volunteers mapped an additional 222 and 32 'other concerns', respectively (Figure 2(b)).

The average time participants spent on the survey was less than 2 h (Table 4). The mean time spent on the survey decreased for every 15 min (Table 5). Most of the participants spent under half an hour on the survey, half of the participants spent under 15 min, and 35.5% spent under 30 minutes. There was a rapid and continuous decrease in the number of participants who participated after 30 min (Table 5).

Volunteer sampling

None of the newspapers contacted before and at the beginning of random sampling published our press release. We advertised in a local newspaper in one of the regions to increase publicity. During the 6 days when the advertisement appeared on their website, it was viewed 7802 times, and 21 persons clicked on the advertisement and proceeded to the survey's web page, resulting in a click-through rate (CTR) of 0.27% (CTR = the number of clicks divided by the number of views). Owing to a rather low outreach percentage and high costs of advertising, we did not advertise in the other regions.

Toward the end of random sampling, we contacted local newspapers again to publish a press release about our survey. Of the 16 local newspapers contacted in Troms and Finnmark, five newspapers published an article about the survey. After finishing with random sampling, we contacted the same 16 newspapers in Troms and Finnmark

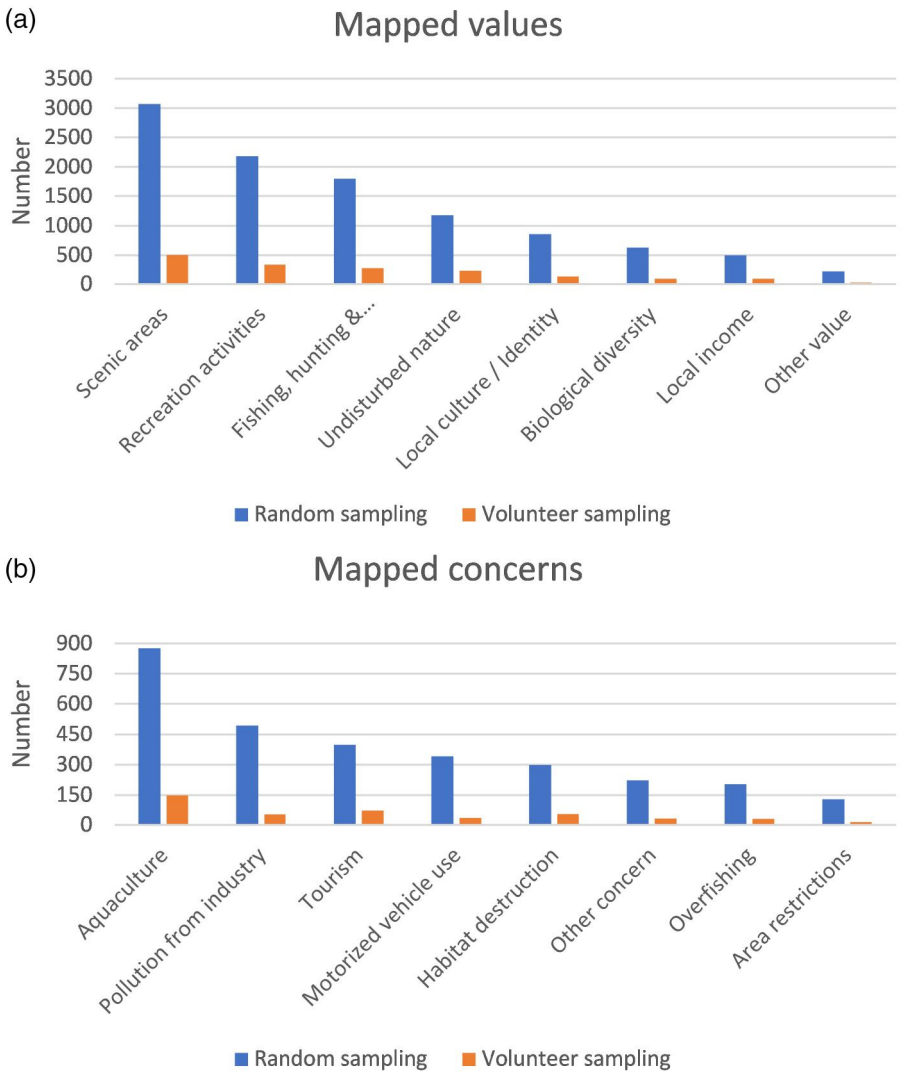

Figure 2. (a) The number of mapped values for random and volunteer sampling. (b) The number of mapped concerns for random and volunteer sampling.

Table 4. The time spent in minutes on the survey among participants in the PPGIS survey in northern Norway.

	Min.	1st Quartile	Median	Mean	3rd Quartile	Max.	N/As
All participants	2	12	16	115	27	10,038	256
Random sampling	2	12	17	115	27	10038	184
Volunteer sampling	2	10	14	111	28	5591	72

and nine local newspapers in Nordland to publish the link to our survey, of which, to our knowledge, at least one newspaper published the link.

We contacted and sent information and links to our survey to all 81 municipalities and 40 larger organizations. To our knowledge, four of them published the survey on their website, social media and/or forwarded the survey to their members.

Table 5. Time spent (minutes) participating in the survey (in 15-minute-intervals) in random and volunteer sampling.

	All participants			Random sampling			Volunteer sampling		
	Minutes (min)	Number of participants	Percentage (%)	Minutes (min)	Number of participants	Percentage (%)	Minutes (min)	Number of participants	Percentage (%)
	15	572	46.5	15	510	45.1	15	62	59.0
	30	439	35.5	30	416	36.8	30	23	21.9
	45	118	9.6	45	107	9.5	45	11	10.5
	60	61	4.9	60	56	5.0	60	5	4.8
	75	24	1.9	75	22	1.9	75	2	1.9
	90	10	0.8	90	10	0.9	105	1	1.0
	105	7	0.6	105	6	0.5	120	1	1.0
	120	4	0.3	120	3	0.3			
Total		1235			1130			105	

Table 6. Results on the social media campaign.

	Facebook	Instagram	Snapchat
People reached	26,720	25,373	N/A
Link clicks	652	384	791
Women	39.1%	61.6%	N/A
Men	60.9%	38.4%	N/A
Age group women	65+	45-54	N/A
Age group men	65+	25-34	N/A

We posted 27 times on our Facebook and Instagram accounts during sampling to increase publicity. We had 284 accounts following us on Instagram and 144 accounts on Facebook when we finished sampling.

Social media campaign

The social media campaign lasted 14 days, during which time the survey link was distributed on the social media platforms Facebook, Instagram and Snapchat (Table 6). More women were recruited on Instagram, whereas more men were recruited on Facebook. Advertising on Facebook reached older people (52.4% of the reached audience presented persons over 65 years old) (Table 6).

Time-cost efficiency

We calculated estimations of personnel-hours for the recruitment process (Table 7), which resulted in 520 h of work. The costs for our PPGIS study resulted in NOK 276,000 (over 23,000 €) (Table 8). Moreover, we calculated an estimated cost per household to be NOK 7.42 (0.64 €) by dividing the costs of mailing addresses received from Evry ASA, letters, reminders, envelopes, advertisements in one newspaper, students helping with folding letters and lotteries by the number of invited participants ($n = 15{,}914$); and an estimated cost per volunteer to be NOK 10.51 (0.90 €) by dividing the costs used for the social media campaign by the number of persons who visited the survey link (Facebook (652), Instagram (382), Snapchat (791), total $n = 1825$). We divided the costs used for random sampling by the number of persons who participated, which resulted in costs of NOK 61.84 (5.32 €) per person (unfinished survey,

Table 7. Estimated hours for the recruitment in the PPGIS study in northern Norway.

Planning and creating survey	300	Estimated duration of eight weeks (37.5 h /week): meetings, planning and creating surveys on two different platforms in Maptionnaire, signing data agreement between Maptionnaire and UiT – the Arctic University of Norway, applying for approval from the Norwegian Centre for Research Data
Planning with communications advisor	7.5	Planning and contacting traditional media before and during sampling
Ordering letters/postcards/reminders	1.5	E-mail exchange with university's postal services
Folding letters	52	Estimating 10 s for folding one letter: 16,978 letters *10 s = 169,780 s, 1875 reminders *10 s = 18,750 s, rest of reminders were postcards (no folding)
Sending letters	1.5	Transporting the letters for mailing, contacting the post office for pick-ups
Social media posts	75	Estimated two full working weeks: planning posts for Instagram and Facebook with a communication specialist
Social media campaign	37.5	Estimated one working week for planning the campaign for Instagram, Facebook, and Snapchat with a communication specialist
Contacting newspapers	37.5	Estimated one working week: sending E-mails to 14 papers to advertise our survey, contacted the same newspapers and in addition 16 newspapers to publish our press release and the survey's link, interviews for $n = 2$ newspapers, e-mailing 81 municipalities and selecting and e-mailing 40 organizations
Advertising in Helgelands Blad	1	E-mail exchange
Answering to telephone calls, E-mails, SMSs and on social media	2.5	Helping participants with the link, answering to questions regarding the survey
Telephone survey	4	Contacting 15 households to ask for non-participation
Total hours	**520**	

Table 8. Costs for PPGIS in northern Norway.

Target	Cost (NOK)	Cost (€)
Maptionnaire license (Three years)	138,900	11,942.62
Mailing addresses from Evry ASA	6900	593.26
Letters for random sampling	13,413	1153.25
Reminders for random sampling	27,558.22	2369.46
Envelopes	17,190	1478
Advertising in newspaper	1600	137.57
Students helping in folding	1400	120.37
Lottery	50,000	4299
Facebook	9575.49	823.30
Instagram	4800	412.70
Snapchat	4799.99	412.70
Total	**276,136.70**	**23,742.23**
*****		
Cost per randomly sampled person in total	7.42	0.64
Cost per volunteer in total	10.51	0.90
Cost per randomly sampled person (unfinished survey)	61.84	5.32
Cost per randomly sampled person (completed survey)	95.36	8.20
Cost per volunteer (unfinished survey)	51.13	4.40
Cost per volunteer (completed survey)	159.80	13.74
*****		
		1 NOK = 0.08598 EUR

$n = 1909$) and NOK 95.36 (8.20 €) per person for those who completed the survey ($n = 1238$). Similarly, we divided the costs used for volunteer sampling by the number of volunteers who participated in the survey, resulting in NOK 51.13 (4.40 €) per person for unfinished surveys ($n = 375$) and NOK 159.80 (13.74 €) per person for those who completed the survey ($n = 120$). These calculations exclude the purchase of Maptionnaire licenses.

Discussion

In this study, we asked how recruitment strategies could be optimized to increase participation in online PPGIS platforms and what the costs of increasing participation are. In the PPGIS survey, the time and resources spent on increasing participation yielded meager results. Advertising in traditional media, posting on social media platforms and conducting social media campaigns did not substantially increase participation in any of the 79 municipalities. Similarly, our synthesis of previous online environmental PPGIS surveys revealed that recruitment is generally low despite the different recruitment strategies applied. Recruitment and response biases are considered the main bottlenecks for improving data quality for planning and decision-making purposes, and whereas this issue has been raised by Brown (2017) and Brown *et al*. (2015b), no one has previously attempted to systematically examine recruitment strategies or calculate the costs of investing in different methods.

Sampling biases and representativeness in PPGIS

Sampling biases are well known in PPGIS (Brown 2017, Hausner *et al*. 2015, Table 2). Representativeness seems to depend upon the topic, with higher participation of middle-aged men with high education and income in topics related to natural resources and the environment (Hausner *et al*. 2015, Brown 2017) and an overrepresentation of middle-aged women (Kyttä *et al*. 2011) and young adults (Kahila-Tani *et al*. 2019) in urban surveys. Women and younger and older participants were underrepresented in our PPGIS study in Norway. The underrepresentation of specific sociodemographic groups has also been noted by others (Gottwald *et al*. 2016), with elderly individuals representing a minority due to their lower internet literacy skills (Kurban *et al*. 2008, Gottwald *et al*. 2016). Ten of the peer-reviewed publications in the literature review provided further insight into low participation. This included, for example, undelivered letters, which was also a challenge in our large-scale PPGIS study in Norway (11.8%). Moreover, the complexity of the survey can be a barrier to participation (Brown and Weber 2012, Schroeder 2014). PPGIS surveys present a relatively complex design due to the mapping component (Gottwald *et al*. 2016), and the lack of usability guidelines could be a reason for participants not completing the survey (Gottwald *et al*. 2016, Brown and Glanz 2018, Garcia *et al*. 2020, Kantola *et al*. 2023). Over half of the published papers in the literature review provided solutions to increase participation, e.g. including instructional videos, conducting nonresponse surveys, and meeting with participants.

Online and offline PPGIS

The usability and applicability of online platforms are among the reasons for the lack of use of PPGIS in planning and decision-making (Rzeszewski and Kotus 2019, Garcia *et al*. 2020). There could also be a general skepticism toward using online PPGIS as a decision tool when participants are not known. Compared with conventional surveys, non-PPGIS online surveys are also known to result in lower participation (Sammut *et al*. 2021). Manfreda *et al*. (2008) performed a meta-analysis comparing online and offline non-PPGIS surveys and reported a lower participation rate of an average of 11% in the

former, which is similar to our finding for online PPGIS. Pit *et al*. (2014) reported that higher monetary incentives, postal surveys, and a mixed method (i.e. a combined online and offline survey) yield greater participation than nonmonetary incentives, small incentives, and telephone and e-mail surveys do. Precontacting participants, personalized packages and sending mail (or invites) on a Friday can increase participation (Pit *et al*. 2014). Commercial companies could yield higher participation rates (Stantcheva, 2023), although we did not find any PPGIS studies using commercial companies.

Precontacting participants and sending surveys at the end of the working week could encourage people to participate more, but incentives have not yielded higher participation in online PPGIS (Brown and Donovan 2014) and did not seem to be the main motivator to participate in our PPGIS either. An instructional video was beneficial to our experience. Our 'how-to-map' in the survey was viewed over 600 times. Rzeszewski and Kotus (2019) question the necessity of utilizing maps in participatory surveys or alternatively suggest adding maps at a later stage into the planning process due to data quality issues. To our knowledge, mapping itself did not create difficulties among participants to a greater extent. Instead, residents called and e-mailed us to ask for help with the website URL, not with the surveying itself. Technical issues are among the reasons for nonparticipation (Kurban *et al*. 2008) or for not completing the survey (Kantola *et al*. 2023). Our telephone survey revealed that one had trouble with the mapping component, one had technical issues, and one showed mistrust, i.e. suspected that the inquiry to participate in the survey was fake. The use of mixed-method surveys has increased overall participation in other studies (Brown and Reed 2009, Brown *et al*. 2012, 2014, Brown and Weber 2012, Pocewicz *et al*. 2012, Pocewicz and Nielsen-Pincus 2013, Schroeder 2014, Brown 2017), but the use of both online and hardcopy survey designs complicates later spatial data analyses, raising validity issues (Brown *et al*. 2017b).

Recruitment efforts to increase participation

A literature review of urban PPGIS revealed that PPGIS can reach a larger audience through volunteer sampling (Kahila-Tani *et al*. 2019). Whereas volunteer mapping can provide more information by recruiting a larger crowd, the quality of the data is lower, as measured by the time spent mapping, the number of locations mapped by each participant and the difficulties associated with assessing the quality and biases of the data when participants are unknown (Brown 2017). The lack of attention to sampling design and response biases was also presented by Brown (2017) as key bottlenecks for advancing the use of online PPGIS for planning and decision-making (Brown 2017).

Meeting physically to help participants with the survey was suggested by Brown and Glanz (2018). Our plan was to organize meeting sites for residents due to the large-scale study area in Norway, but this was cancelled because of the COVID-19 pandemic in 2020 and 2021, during which time data gathering took place. Notably, while meeting physically can serve especially those with less internet literacy, this recruitment method has not enrolled many participants in PPGIS surveys (Brown and Glanz 2018). We suspect that other challenges with recruitment related to the COVID-19 outbreak could include excessive online communication related to work or schooling of children, but we were not able to assess this in our pilot study.

The efforts of recruitment associated with PPGIS studies measured in time, effort and costs have also been raised recently by Kantola *et al*. (2023). In their case, participation increased every time the survey was promoted actively through different channels (Kantola *et al*. 2023). We calculated that approximately 500 h, i.e. approximately three months of work, were needed for recruitment for the PPGIS in northern Norway, including an approximate NOK 276,000 (24,000 €) for random and volunteer sampling. The total costs per participant were NOK 7.42 (0.64 €) per person for those recruited by random sampling and NOK 10.51 (0.90 €) per person recruited by volunteer sampling. The costs per person for those who did participate were high (ranging between NOK 51.13 and NOK 159.80/4.40 € and 13.74 €). We did not observe an increase in participation despite the efforts or the costs used. Could it simply be that despite the growing use of the internet, the number of available online surveys (Ball 2019) has resulted in research fatigue and an increased unwillingness to participate, especially in a more complex survey such as PPGIS? We carried out a lottery for randomly sampled residents to increase interest in participating, and although incentives have been shown to have a positive effect, they have simultaneously leveraged only a modest outcome compared with PPGIS participation rates in surveys that did not use incentives (Brown and Donovan 2014). Participation rates have been low even when participants are aware that their answers will contribute to marine spatial planning (Strickland-Munro *et al*. 2016).

Conclusion

Using different recruitment methods before and during sampling in the large-scale PPGIS in Norway did not lead to a substantial number of finished surveys, and the time and costs spent did not yield a higher participation rate than did PPGIS studies in general. Our PPGIS study could also be seen as 13 small-scale comparative PPGIS studies since we provided participation rates separately for each region (Table 3), and the recruitment effort per site did not explain the low degree of participation. Online PPGIS is not widely used in environmental decision-making and planning because of the reasons mentioned above and the lack of engagement of end-users (Kantola *et al*. 2023). However, PPGIS is a relatively new survey tool that has been used for a relatively short time (Brown and Weber 2012). Despite the low participation rates, we see the promise of this platform and suggest further research in recruitment efforts so that data received from PPGIS can be presented as a practical tool and implemented in monitoring, planning and decision-making. Furthermore, as argued by Kantola *et al*. (2023), stronger engagement by decision-makers in the design and promotion of a platform could increase the participation rate.

Recommendations

We recommend investing in recruitment strategies that have not yet been explored in online environmental PPGIS surveys. We used social media and newspapers as a part of our broader social campaign but did not test other media, e.g. television and podcasts, and which had not previously been used for recruitment in the literature we surveyed. The time and effort spent recruiting people could also justify the use of a

professional recruitment company to increase participation. On a smaller scale, facilitated workshops or other more intensive recruitment efforts could be applied, although this would have been too costly in our study area of 81 municipalities in remote parts of northern Norway. Successful online PPGIS recruitment is dependent not only on internet access and literacy but also on investigating the geographical popularity of different social media platforms. To better grasp how recruitment and response biases influence the quality of the mapping and data for decision-making, it is important to implement more studies in different parts of the world by testing different ways of engaging participants.

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Data and codes availability statement

The link to the anonymous dataset including mock data and codes: https://doi.org/10.18710/8ACZ2A.

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